# First responder thermal imaging cameras:

## representative testing conditions & performance metrics

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# Overall Research Objectives

- **Assess the thermal imaging activities and needs of first responders.**

- **Establish a range of testing conditions that simulate the operating environment.**

- **Determine the extent to which the camera display effects the performance of the camera.**

- **Evaluate the effects of human perception.**

- **Identify appropriate imaging performance metrics and develop standard performance testing methods.**
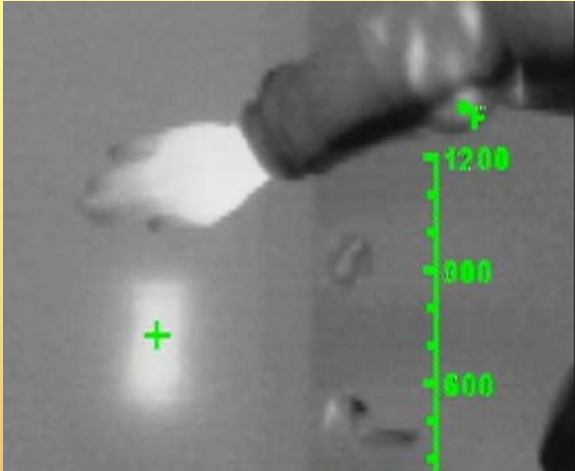
# Approach

- **User Input: TIC operations**
  - Workshop on Thermal Imaging Needs for First Responders

- **Existing standards/ Relevant work by others**
  - Thermal classes
  - Literature sources

- **Full-scale tests/ Bench-scale tests**

- **Propose TIC testing conditions**

- **Develop image quality performance metrics**

- **Recommend standard test methods**

# TIC Operations- A Sampling

**Locate fire sources**

**Navigation in smoke/dark**
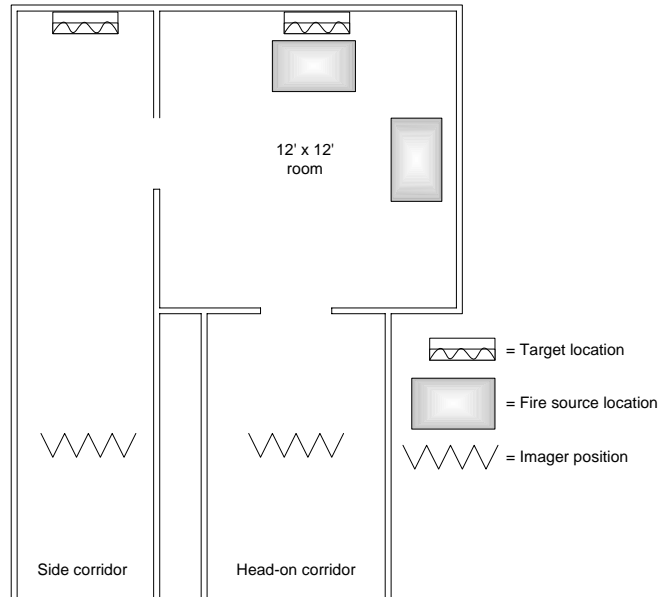
**Overhaul**

**Find firefighters**

**Find victims**

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# Consolidation

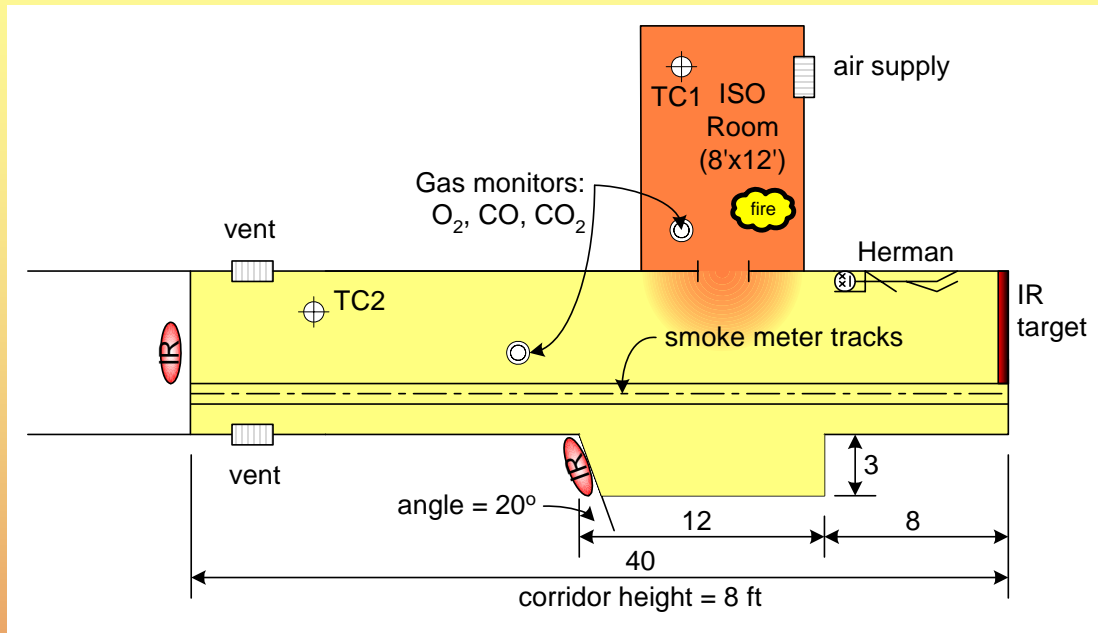| | Class I | Class II | Class III |
|---|---|---|---|
| **Class** | *water, fog, or snow possible, minimal heat, smoke and flames* | *elevated temperatures, water, dust, smoke and flames may be present* | *high temperatures and smoke concentrations, flames, dust, and water are likely* |
| **Activity** | Hazmat<br>Medical<br>Motor vehicle accident<br>Search | Overhaul<br>Size up<br>Tactics<br>Forensics<br>Preventative maintenance<br>Search | Forensics<br>Wildland fires<br>Size up<br>Tactics<br>Communication<br>Search |
| **Proposed Tests** | Contrast<br>Obscurants<br>Spatial Resolution<br>Thermal Sensitivity<br>Uniformity | Contrast<br>Obscurants<br>Effective Temperature Range<br>Spatial Resolution<br>Thermal Sensitivity<br>Uniformity | Contrast<br>Obscurants<br>Spatial Resolution<br>Thermal Sensitivity<br>Uniformity |

# Full-Scale Tests (I)



12' x 12' room

☰ = Target location

▢ = Fire source location

∨∨∨ = Imager position

Side corridor

Head-on corridor

# Full-Scale Tests (II)



- **Imagers in upper and lower layer**
- **Targets: exit signs, mannequins, controlled temperature target**
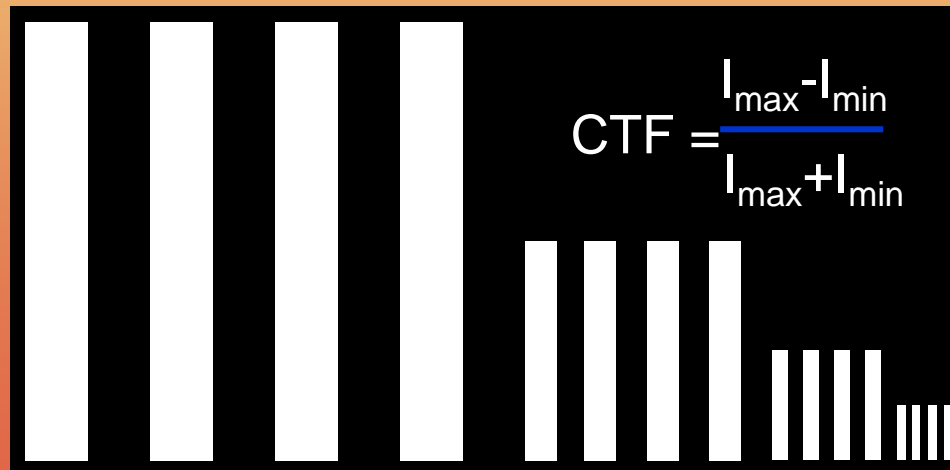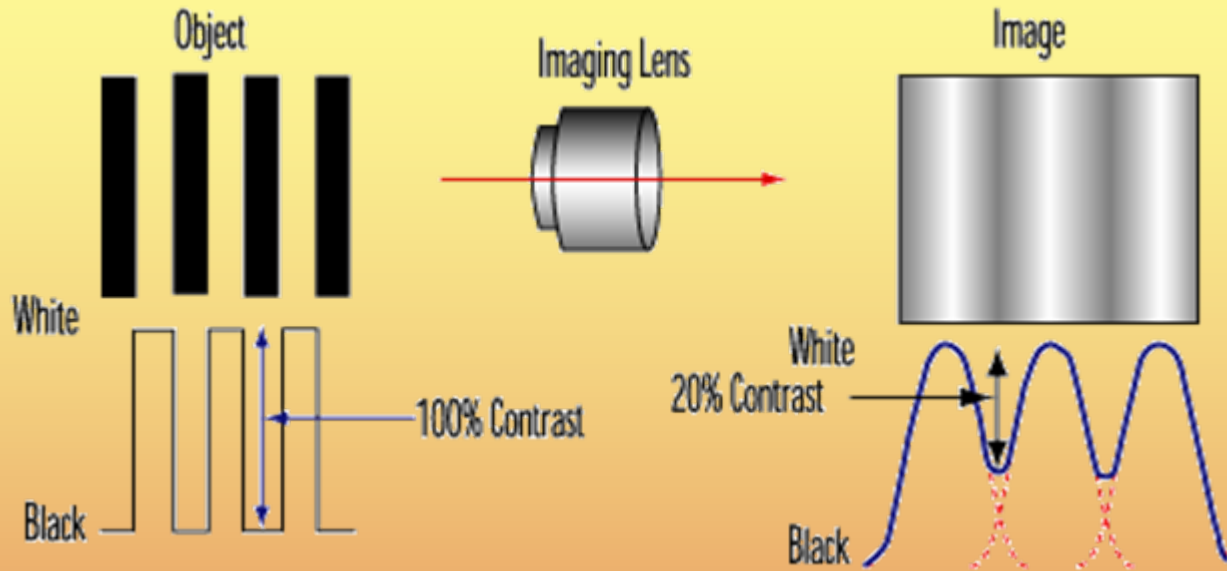- **Soot, dust, steam, water, varying fuels**
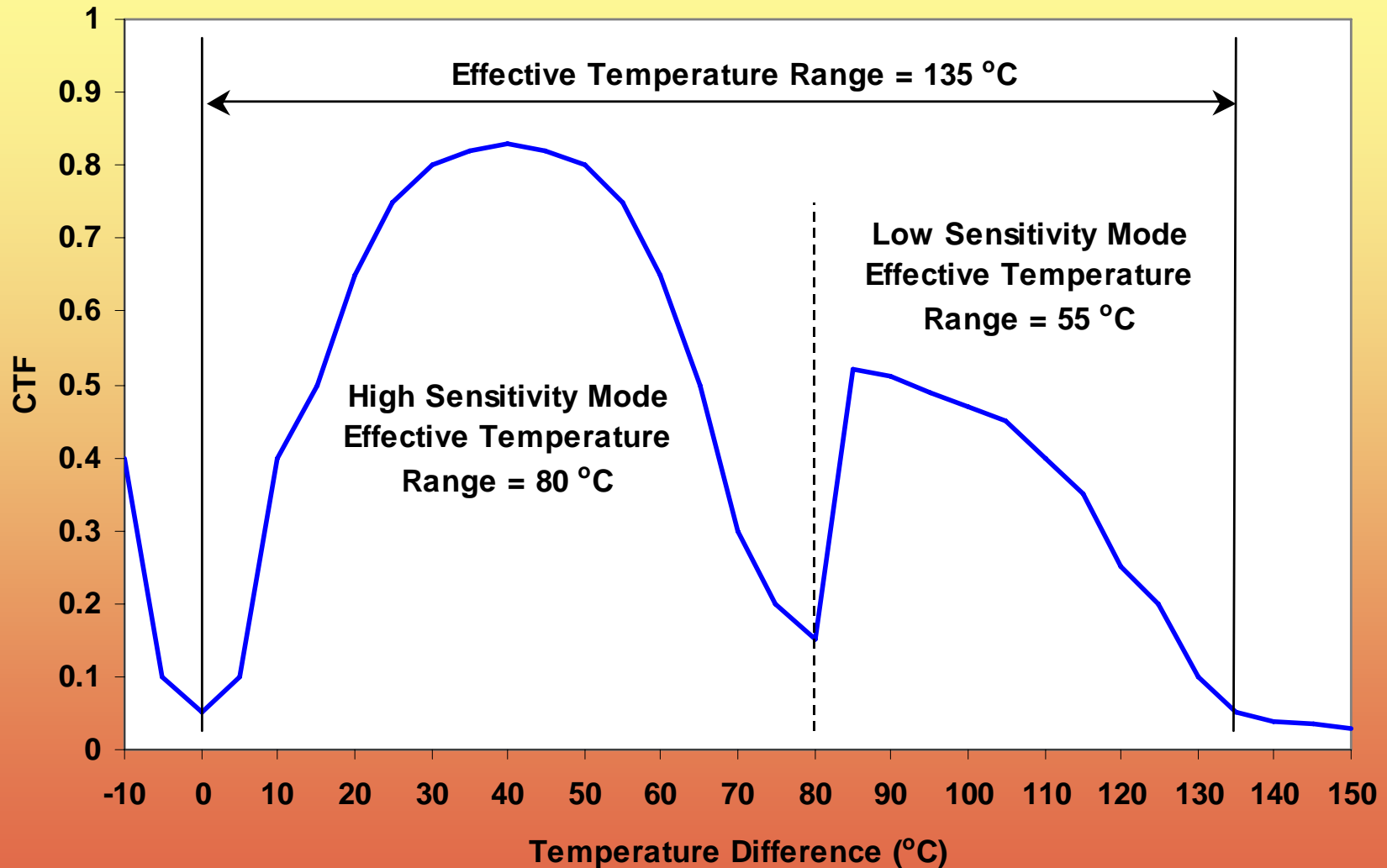
# Performance Metrics

- **Contrast & Effective Temperature Range**
  - Determine the point at which the *displayed image* loses its usefulness

- **Electro-Optical Transfer Function (EOTF)**
  - Relationship between displayed image and captured video output

- **Obscurant Effects**

- **Spatial Resolution**
  - Not directly dependent on thermal target
  - Use random MTF target?

- **Thermal Sensitivity**
  - Perceivable thermal sensitivity, viewing targets in various thermal classes
  - Camera itself exposed to elevated temperatures
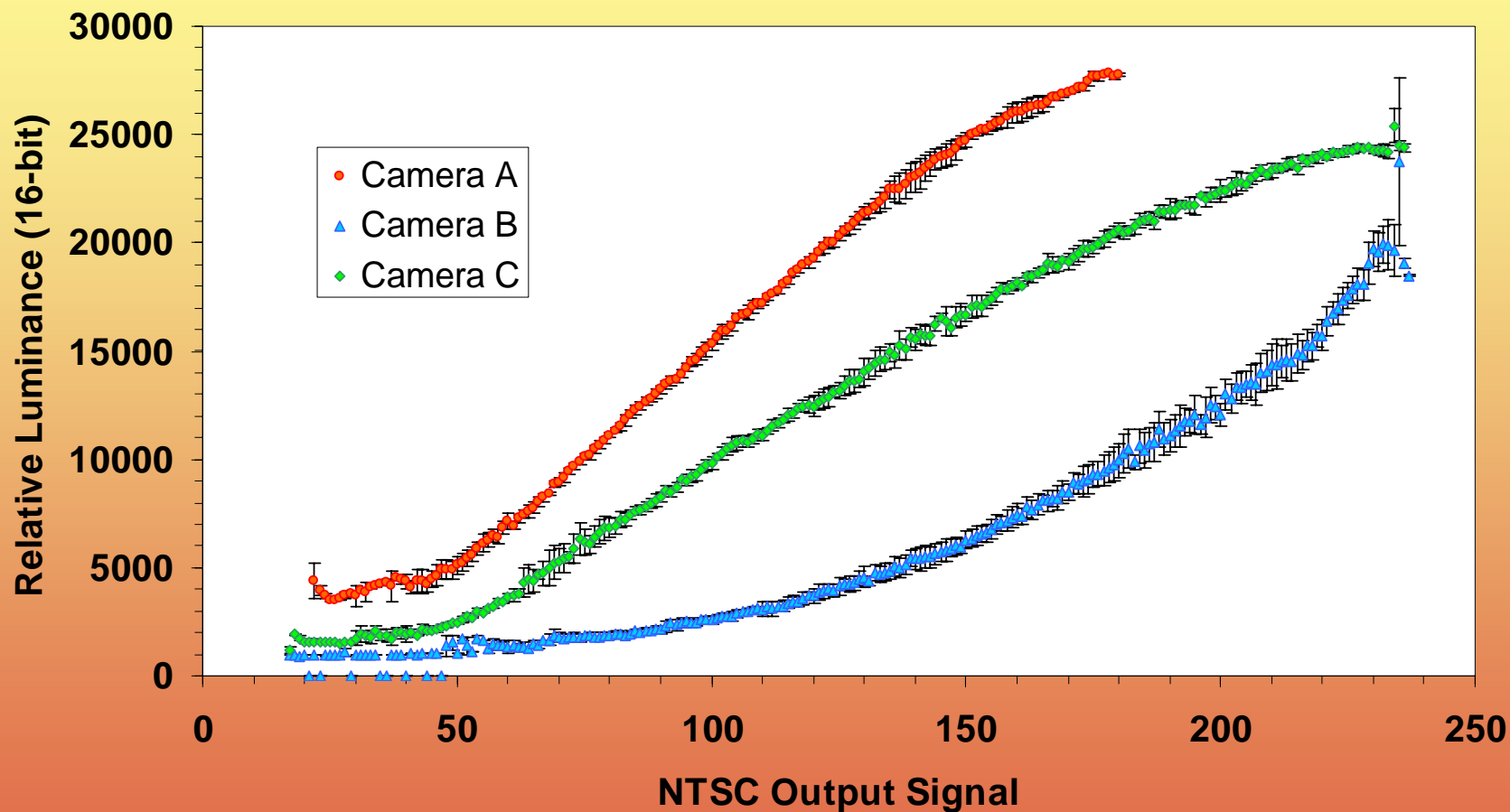
- **Uniformity of Display**
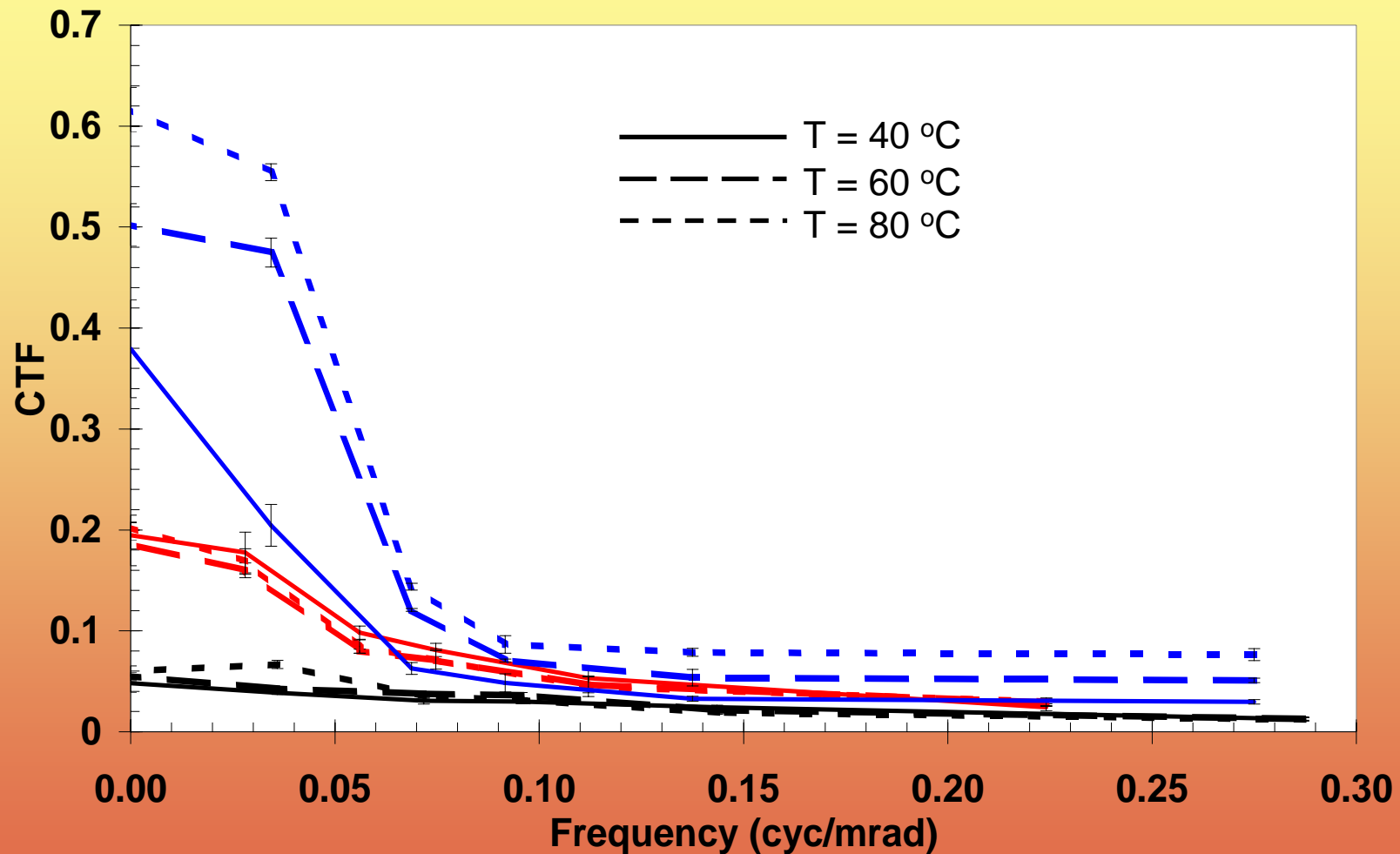
# Contrast Transfer Function



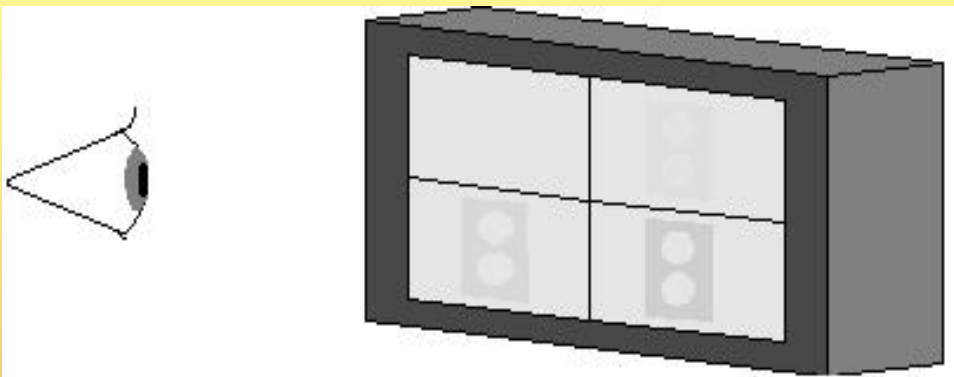$$CTF = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$

# Contrast & Effect Temp Range



**Effective Temperature Range = 135 $^o$C**

**Low Sensitivity Mode Effective Temperature Range = 55 $^o$C**

**High Sensitivity Mode Effective Temperature Range = 80 $^o$C**

CTF

Temperature Difference ($^o$C)

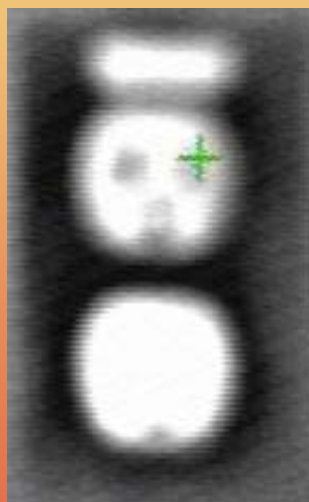# Electro-Optical Transfer Function

# Spatial Resolution

# Thermal Sensitivity



**Potential targets include electrical outlets, light ballasts, vents, windows, and people.**



**Visible**    **Infrared**



Luminance Meter

Frustum

Thermal Imaging Camera

Target

Blackbody
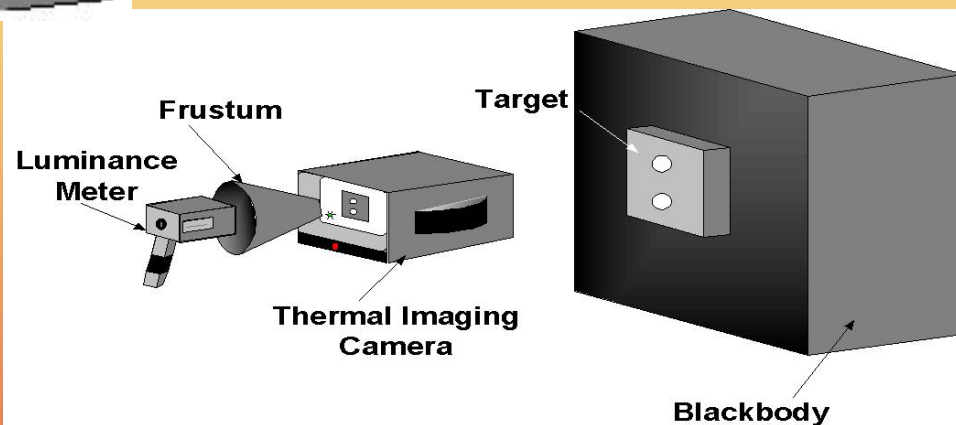
# Collaborations & Future Work

- **NIST Physics Lab**
  - Hyperspectral projector

- **NIST Electronics and Electrical Lab**
  - Display measurements

- **Night Vision Lab**
  - Test human perception of displayed thermal images

- **OLES**
  - Field calibration target
  - Non-fire environments

- **University of Central Florida**
  - Random MTF target development

- **Standards committees: ASTM, NFPA, FSTICWG**

- **Simulated obscurants for bench-scale tests**

# Acknowledgments